

THE COMPARATIVE ANATOMY OF THE STEMS OF BETULA PUMILA, BETULA LENTA, AND THE HYBRID BETULA JACKII

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PROFESSOR JACK(1), in 1895, described a hybrid *Betula*, afterwards named *B. Jackii* by C. Schneider, six individuals of which appeared in a group of several hundred seedlings grown at the Arnold Arboretum. The seed from which the plants were grown was collected from a plant of *B. pumila*, the Dwarf Birch, growing about one hundred paces east of several trees of *B. lenta*, which was the only other species growing in the vicinity, whose pollen would be carried to it by the winds. Jack described the characters of the hybrids and showed that of the six plants four were morphologically intermediate in all ways between *B. pumila* and *B. lenta* and had the aromatic smell characteristic of *B. lenta*, though to a lesser degree. The other two plants were more like *B. pumila* than *B. lenta*, and had little or no aromatic odor.

In 1929 Professor Woodworth(2) described his cytological investigation on the reduction divisions of *B. pumila*, *B. lenta* and *B. Jackii* in material collected at the Arnold Arboretum, the results of which substantiate Professor Jack's conclusion that *B. Jackii* is a hybrid between *B. pumila* and *B. lenta*. Professor Woodworth said that "Meiosis and pollen formation are typically normal in both the parents," but that *B. Jackii* displays to a marked degree the meiotic irregularities characteristic of hybrids—abnormality of gemini formation, lagging of chromosomes, extrusion of chromosomes into cytoplasm, polyspory, and partial sterility of pollen; he concluded that *B. Jackii* is a hybrid between the diploid *B. lenta* and the tetraploid *B. pumila*.

In view of these investigations it seemed worth while to study the stem anatomy of the three species.

MATERIAL AND METHODS

Material was collected in 1928 from labeled plants at the Arnold Arboretum, killed in Carnoy's, imbedded, sectioned, stained with Heidenhain's iron hematoxylin and safranin, and studied. To check the results obtained, material was again collected in 1933 at the Arboretum, but from individual plants other than those from which the first collections were made, sectioned and stained without imbedding, and

studied. The ages, according to annual ring count, of the oldest specimens studied for each species are:

<i>B. pumila</i>	24 years
<i>B. lenta</i>	18 years
<i>B. Jackii</i>	14 years

The plants of *B. Jackii* were morphologically intermediate between the parents.

COMPARATIVE ANATOMY

All three Birches have a typical woody siphonostele. The differences in anatomy which seem significant are as follows:

PHLOEM SCLERENCHYMA

In all three Birches, groups of phloëm cells become sclerenchymatized, but the locations of the sclerenchymatous tissues in them differ as follows:

B. pumila: phloëm cells that are to become sclerenchyma enlarge and their walls thicken soon after they are formed, consequently the sclerenchymatous bands almost touch the cambium, and depress it. This depression of the cambium under the sclerenchyma masses results in wavy or scalloped annual rings, a characteristic feature after the first year or two of growth. The sclerenchyma masses show a tendency to be continuous radially, that is, to appear as radial bands in transverse section.

B. lenta: walls of phloëm cells that are to become sclerenchyma do not thicken until several years after the cells have formed; consequently there is no sclerenchyma near the cambium, the cambium is not pressed inward, and the annual rings are not scalloped. The sclerenchyma masses do not show any tendency to be continuous radially (but sometimes a slight tendency to be continuous tangentially); they appear in transverse section as small, more or less isodiametric areas.

B. Jackii: as in *B. lenta*, walls of phloëm cells that are to become sclerenchyma do not thicken until several years after the cells have formed, so there is no sclerenchyma near the cambium, and no depression of the cambium or scalloping of the annual rings. The sclerenchyma masses appear in transverse section as small, more or less isodiametric areas; but they differ perhaps from those of *B. lenta* in that they seem sometimes to be nearer the cambium, and show practically no tendency to merge tangentially.

"AGGREGATE RAY" AREAS

B. pumila: the wood formed by the depressed cambium, under the sclerenchyma masses, has an aggregate ray-like appearance in that it lacks vessels and is composed wholly of rays and fibers; the fibers, especially in older wood, differ from the usual fibers near vessels in the following respects: they are greater in diameter, they are one-fourth to one-third the length of the usual fiber, their ends are oblique or bluntly tapering instead of long and tapering, and they tend to twist and intertwine instead of being comparatively straight up and down. These areas are usually apparent in transverse section in the second or third annual ring, and broaden as they extend out to the cambium.

B. lenta and *B. Jackii*: no such "aggregate ray" area was apparent in any of the specimens of the pollen parent or the hybrid that were examined.

VESSELS

The differences between the vessels of the three Birches are small; perhaps if a larger group of specimens was studied they would be found not valid, but in the specimens studied these generalizations seem to hold:

B. pumila: vessels are more or less in radial rows, rather angular, small, and somewhat more concentrated in the spring wood.

B. lenta: except in the first ring, where the vessels resemble those of *B. pumila* in size and distribution, the vessels are in rounded groups of one to about four, or less frequently in radial rows; the groups are scattered evenly throughout the annual ring; the vessels themselves are large and rounded. In radial sections the wood of *B. lenta* can be distinguished from that of the other two types by the fact that the ends of the larger vessels have the bars of the scalariform perforation fewer and further apart than do those of either of the other two forms; the bars are about 12 microns apart in *B. lenta*, and 3.8 to 6 microns in *B. pumila* and the hybrid.

B. Jackii: vessels are in rounded groups or radial rows and are perhaps slightly more concentrated in the spring wood. The general appearance of the transverse section is more like that of *B. lenta* but differs from it in that the groups of vessels seem fewer and further apart and the vessels themselves perhaps smaller.

RAYS

All three Birches have simple rays and small compound rays; the

width in cells of the largest of the compound rays seems to be a specific character. The walls of the cells seem to vary in thickness and regularity in the same way in which the walls of the pith cells vary (see below), but to a lesser degree.

B. pumila: the rays are mostly simple, one cell wide, some are compound, two cells wide, and in the "aggregate ray" area some individual rays appear in tangential section to be three cells wide, although this appearance may be due to twisting of cells in the area. In general, however, the rays are not more than two cells wide even in the twenty-fourth annual ring. The walls of the ray cells are more or less irregular, but much less definitely and constantly so than the walls of the pith cells.

B. lenta: rays are from one to three cells wide even in the earlier rings (about the second to sixth); in older wood (about the fifteenth ring), they may be four cells wide. The walls of the ray cells are thickened fairly evenly, but not as evenly as those of the pith cells.

B. Jackii: rays are one, two, and occasionally three cells wide in the earlier rings, often three cells wide in the later ones (about the twelfth). In tangential section *B. Jackii* resembles *B. lenta* more than *B. pumila*. The cell walls are thickened somewhat irregularly; but in all three kinds the characters of the ray cell walls are too similar and inconstant to be of value in distinguishing the species.

PITH

The pith cells of the two parent species present quite distinct and different characters, and those of the hybrid seem intermediate between them. The distinguishing wall characters are seen best in transverse section.

B. pumila: the secondary thickening of the wall is irregular, so that the wall extends into the cell lumen as blunt projections between which are canals of varying diameter ending in simple pits. The thickness of the wall, from the lamella to the inner points of the projections, is usually 7 to 10 microns, about four times that of the wall of the pith cells of *B. lenta*. In longitudinal section the cells are usually twice as long as wide, or longer.

B. lenta: the pith cell wall is thickened evenly so that its inner surface is parallel throughout with its outer one; it is 2 to 3 microns thick and is pierced by pits of constant diameter. The cells are usually less than twice as long as wide (often they are isodiametric), although exceptions occur, especially near the outside edges of the pith.

B. Jackii: the pith cell wall is slightly irregular and about 2 to 5 microns thick; the diameter of its pits vary somewhat. The cells range from isodiametric to more than twice as long as wide. In general the pith cells of the hybrid seem to be intermediate between those of the two parents.

SUMMARY

Betula pumila and *Betula lenta* have several distinct anatomical characteristics; in some of them the hybrid, *Betula Jackii*, seems more or less intermediate—size and distribution of vessels, width in cells of compound rays, proportions and wall characteristics of pith cells.

In other respects the hybrid resembles *B. lenta*, its pollen parent, since they both lack completely in the specimens studied the "aggregate ray" areas, the scalloped cambium and annual rings, and the early-forming phloem sclerenchyma that characterize *B. pumila*.

In the character of the perforations of the vessel ends the hybrid is unlike *B. lenta*, and closely resembles *B. pumila*.

The writer wishes to acknowledge the kindly suggestions and assistance of Professor R. H. Woodworth, under whose direction this work was done.

LITERATURE CITED

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